(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 July 2003 (10.07.2003)

PCT

(10) International Publication Number
WO 03/056232 A1

(51) International Patent Classification[7]: F17C 5/02, 7/02

(21) International Application Number: PCT/NO02/00493

(22) International Filing Date:
20 December 2002 (20.12.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20016354 21 December 2001 (21.12.2001) NO

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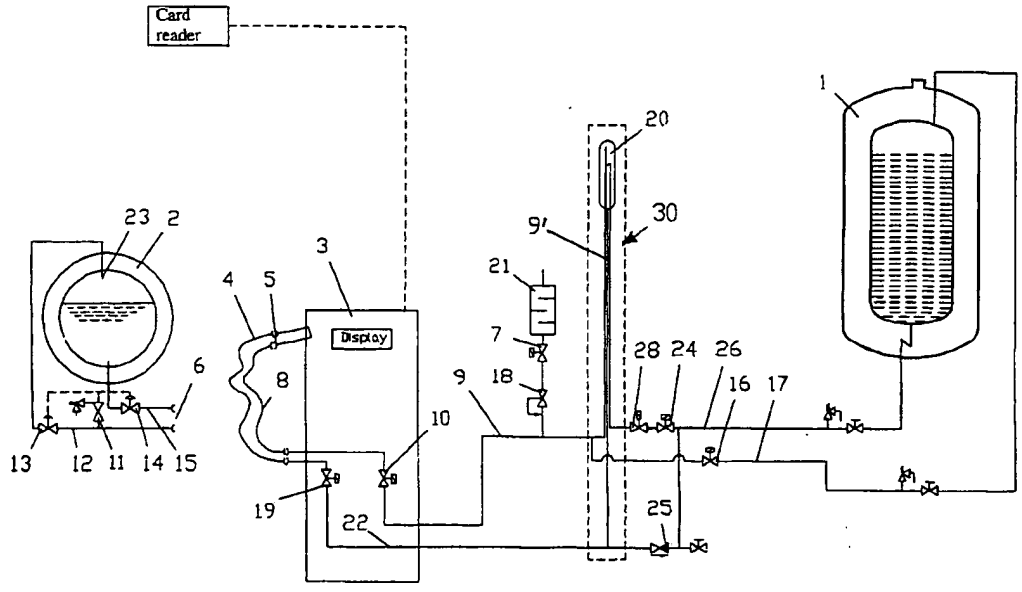
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: FILLING STATION FOR THE FILLING OF FLUIDS AND A METHOD FOR SAME



(57) Abstract: A method for distribution and sales of cryogenic fluids, in particular CO_2 includes a system of filling stations for cryogenic fluids provided in connection with ordinary service stations for the filling of fuels to motor driven vehicles. The filling stations for cryogenic fluids include at least a stationary storage tank (1) and dispenser (3) with flexible hoses (4, 8) and a quick connector (5) for easy connection to a mobile tank (2) on a truck or the like. The filling station further includes a pressure/flow control column (30) with a phase separator (20) provided between the stationary storage tank (1) and the dispenser.

WO 03/056232 A1

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Filling station for the filling of fluids and a method for same

The present invention relates to a method for distribution and sales of cryogenic fluids and a filling station for the filling of fluids, in particular cryogenic refrigerants such as CO_2, from a storage tank to a mobile tank for instance on a vehicle, the filling station including beyond the storage tank and required piping, a dispenser with metering equipment for metering the fluid and a filling hose with connector for connection to the mobile tank to be filled.

Air conditioning and refrigeration systems of the type used to cool or keep frozen the loads on large trucks and trailers are conventionally based on closed vapor compression cycles. One alternative to the closed vapor compression cycle is the use of cryogenic refrigeration system utilizing either liquid carbon dioxide or liquid nitrogen.

The CO_2 is provided in a transportable tank mounted inside the refrigeration unit or at the chassis of the truck. Inside the refrigeration unit the CO_2 is vaporized in an air/CO_2 heat exchanger. The cooled air from this heat exchanger is blown into the goods compartment of the vehicle.

Such a system is particularly attractive because, in addition to eliminating the need for chlorofluorocarbon (CFC) or similar refrigerants which are detrimental to the stratospheric ozone, it also eliminate the needs for a refrigerant compressor and the diesel engine or other prime driving unit that drives the compressor. An example of such cryogenic refrigeration system that is designed for use with liquid carbon dioxide is described in US patent No. 5,730,216.

Another prior art reference, US 5 916 246 describes a system and method for transferring liquid carbon dioxide from a storage tank to a truck transportable tank with lower pressure. The system includes an inlet conduit having a hose portion connected between the storage and transportable tanks for conducting a flow of liquid carbon dioxide therebetween and a vent hose connected to the transportable tank for venting gaseous carbon dioxide.

One disadvantage with the system according to US 5 916 246 for transferring liquid CO_2 is that the CO_2 loss is relatively high since gaseous carbon dioxide, created as a result of

flashing when the pressure of the liquid carbon dioxide is reduced from high pressure in the storage tank to low pressure in the transportable tank, is vented off directly to the atmosphere. Further, as CO_2 is introduced into the transportable tank in both a liquid and a gaseous phase the system will suffer from unwanted long filling periods and difficulties related to flow measurements.

The known filling system is designed to be placed on special truck sites, for instance at or near the garage of the truck owner or warehouse storage and requires a skilled operator to use the system. The known system further requires a skilled person to operate it as the filling operation is not fully automated.

The present invention provides a system for distribution and sales of cryogenic liquid gases, in particular carbon dioxide, that is easily accessible for public use by truck drivers and other users that require quick filling of mobile cryogenic tanks or accumulators. The system works independently of the level and pressure in the stationary storage tank. The inventive system further needs no transfer pump for transfer of the liquid gas from the storage tank to the mobile tank, whereby the system is more reliable and maintenance costs are reduced. With the present invention it is possible to transfer CO_2 to the transportable tank that is mainly in a liquid phase, which speeds up the filling procedure.

Further, the measuring of the transferred liquid under filling is simple and reliable. The filling takes place for instance through a quick connector such as a two-port one-piece connector and no manual valves needs to be operated by the operator before or after filling which makes the system easy to use. And, still further, the filling system is accessible by use of credit card and the user can thereby be invoiced through ordinary credit card systems.

The method according to the invention is characterized in a system of automated filling stations for cryogenic fluids, where the filling station for cryogenic fluids including at least a stationary storage tank (1) and dispenser (3) with at least one fluid dispensing means (4, 8) and a quick connector (5) for easy connection to a mobile tank (2) on a truck or the like as defined in the attached independent claim 1.

The filling station according to the invention is characterized in that a pressure/flow control column (30) with a phase separator (20) provided between the stationary storage tank (1) and the dispenser (3), as defined in the attached independent claim 6.

Preferred embodiments of the invention are further defined in the dependent claims 2-5 and 7-16.

The invention will be further described in the following by way of example and with reference to the attached drawing showing a schematic representation of a system according to the invention.

Fig. 1 shows in a first embodiment a filling station,

Fig. 2 shows in a second embodiment a filling station.

The filling station of Fig. 1 includes as can be seen in the drawing three main components; a stationary storage tank for liquid CO_2 1 a pressure/flow control column 30 (phase separator 20), and dispenser cabinet 3. These main components are interconnected by means of liquid CO_2 piping 26 from the storage tank 1 to the phase separator 20 with a branch pipe 22 to the dispenser, and gas pipe 9 from dispenser with branch pipes 9', 17 to the phase separator 20 and tank 1 respectively.

The stationary storage tank 1 is a standard insulated tank used for different CO_2 applications. At different filling stations the tank size will vary form 12 to 50 m^3 depending on the gas turnover at the site. The storage tanks are filled from CO_2 trucks operated by a gas supplier.

Inside the pressure/flow control column 30 the liquid CO_2, during mobile tank filling is depressurized, phase separated and measured. The pressure inside the storage tank 1 is normally higher than what is the situation in the mobile tank. Therefore the pressure inside the column is reduced by using a back pressure regulator 18. The pressure reduction causes the liquid CO_2 to flash, and it produces a mixture of liquid and vapor phase inside the column 30. The two phases are separated in a phase separator 20, and the liquid phase going to the mobile tank is measured. The vapor phase is released to the atmosphere. Alternatively, the vapor phase may be recompressed and liquefied and put back into the storage tank 1 if it is economically practical to do so.

The phase separator 20 is placed at the upper end of the pressure/flow control column 30. On top of the separator the gas phase inside is through pipes and hoses connected to the gas phase of the mobile tank 2 to be filled. During filling operation the two tanks are also connected through the liquid phase. Since the phase separator 20 is located on a higher level than the mobile tank 2, the liquid in the phase separator will, due to gravity, flow into the tank. Gravity is the only driving force used to fill the mobile tank. This effect also guarantees sub cooled liquid CO_2 at the bottom of the pressure/flow control column 30. This provides ideal conditions for flow measurements without using a density meter.

Inside the dispenser cabinet 3 a flow measurement processor (not shown in the drawing) is located. This unit reads the signals from different transmitters in the measurement system (not shown) and calculates the actual flow delivered from the dispenser. The flow is presented on a display mounted on the dispenser cabinet 3. The processor also works as a programmable logic controller (PLC) that operates the different valves in the system during filling and communicates with the credit card reader system.

The dispenser cabinet 3 is also equipped with necessary hoses 4, 8 and couplings respectively for evacuation of excess gas if necessary and filling of liquid CO_2 to the mobile tank. The coupling for connection of the hoses 4, 8 to the mobile tank is preferably but not necessary in the form of a two-port quick connector 5 (not shown in detail) that connects both the liquid 8 and gas hose 4 in one operation. The quick connector has shut off valves that close when uncoupled. It can be coupled and uncoupled even when pressurized. Alternatively the coupling may consist of separated hose connections.

The shut off valves associated with the mobile tank can be operated by gas pressure from the dispenser. The valves therefore open automatically when the quick connector is connected. The operator does not have to operate any valves during filling. The filling hoses are equipped with breakaway couplings (not shown) to avoid major gas leakage if the vehicle with the mobile tank should be moved before the hoses are disconnected.

Working principle in detail:
The sequence for mobile tank filling starts when the truck driver uses his credit card in the card reader (not shown in the drawing). It should be understood that any appropriate credit

means or system such as automatic or manual cash payment can be utilized in accordance with the invention. By credit accept, the filling station is released for filling.

Next step is that the operator connects the filling hoses 4 and 8 by disconnecting the quick connector 5 (not shown in further detail) from the resting position on the dispenser 3 and fitting it to the corresponding (male) connector 6 associated with the mobile tank (not shown). Immediately after the connector has been moved from its resting position, valve 7 opens and gas being present in the gas evacuation hose 8 and connected piping 9 corresponding to pressure above 8 bars is released to the atmosphere. The pressure in the gas hose 8 will then be approximately 8 bars when it is connected to the truck as valve 10 on the piping 9 also functions as a check valve.

As the connection is accomplished, gas at a pressure provided in the gas hose will pass through a valve 11 on the gas evacuation piping 12 on the mobile tank and pressurize the actuators of valves 14 and 13 provided on the liquid CO_2 filling piping 15 and gas evacuation piping 12 respectively. Both valves will open. If the pressure now stabilizes at 6 to 8 bars, the system is ready to start filling. If the pressure drops, the mobile tank 2 must have been unpressurized, and need to be filled with gas phase. It should be understood that the pressure can be detected for instance by means of sensors (not shown). The filling of gas phase into the tank is automatically accomplished by opening of valve 10 on the piping 9 and valve 16 on the piping 17 on the stationary filling station such that gas is transferred from the gas phase of the stationary tank 1 to the mobile tank 2 until sufficient pressure is reached.

Alternatively, the valves 14 and 13 can be of a non-pneumatic design with built-in check valves incorporated in the filling connector. The valves open when connected with connector 6 associated with the mobile tank 2. This action can be performed by mechanical means or the equivalent known by the person skilled in the art that manipulates the valves as the connectors are brought together.

The operator must now press a "Start " button on the dispenser cabinet 3 if provided. Alternatively, the system can be adapted for automatic start of filling when sufficient pressure is reached or by other appropriate initial conditions achieved. Valves 10, 19 and 24 then opens. Liquid CO_2 is now fed from the stationary storage tank 1 into the phase separator 20. Gaseous CO_2 is led from the separator 20 to the atmosphere through a muffler 21 via

a back pressure regulator 18 and the valve 7. Liquid CO_2 is filling the pressure/flow control column 30 and is further transported via liquid filling piping 22, the hose 4 and mobile filling piping 15 into the mobile tank 2. The measurement system provided in the dispenser cabinet (not shown) starts reading. The gas phase in the mobile tank 2 that is displaced due to the filling of the liquid CO_2 flows through the gas evacuation hose 8 and is discharged to the atmosphere through the muffler 21 via the piping 9 and valves 18 and 7.

This process will continue until the mobile tank is full. The tank is full when the liquid level in the tank exceeds the position of the end 23 of the gas evacuation pipe 12. The return gas form the tank will then contain liquid droplets which are detected by an overfill sensor (not shown) in the cabinet 3. The sensor provides signals to valves 7, 10, 19 and 24 to close the valves and filling is then stopped. The flow measurement reading then also automatically stops, and a signal is sent to the display of the cabinet 3 informing the card reader of the quantity of gas filled into mobile tank 2.

The operator will now disconnect the (female) filling connector 5 on the hoses 4, 8 from the truck and fit it into its resting position on the dispenser cabinet 3. The valves 13 and 14 will then close within a few seconds. That happens because the gas operating the actuators will leak out from the system through a small hole (not shown) for instance drilled in a non return sleeve in connector 6 (not shown).

The hoses 4, 8 and the pipes 9 in the fill station are now partly filled with liquid CO_2. This liquid will evaporate and cause the pressure in the system to rise. When the pressure exceeds storage tank pressure the remaining liquid will be forced back to the tank through check valve 25 provided on the liquid filling pipe 22. This valve is located at the lowermost level in the piping system to make as much liquid as possible return to storage tank. Valves 10 and 19 are also functioning as check valves such that the hoses 4, 8 will be drained from liquid. When the system is drained the pressure in the pipes will be slightly higher than in the storage tank.

The system will be ready to start a new filling immediately after the former filling has been completed. It is not necessary to complete the draining of liquid to get ready for a new start.

It should be understood that the hoses 4 and 8 may be integrated into one flexible line, comprising twin hoses or coaxially arranged hoses.

Further, in one embodiment a boost pump can be arranged in line 22 to speed up filling procedure if wanted.

Figure 2 shows another embodiment of a filling station. As in the previous example, the filling station includes three main components; a stationary storage tank for liquid CO_2 101 a pressure/flow control column 130 (phase separator 120), and dispenser cabinet 103. These main components are interconnected by means of liquid CO_2 piping 126 from the storage tank 101 to the phase separator 120 with a branch pipe 122 to the dispenser. The gas phase circuit comprises branch pipe 109' to separator 120, being connected with branch 117 to the storage tank 101 and one branch preferably comprising a muffler 121. The stationary system may further comprise valves and control regulators, card reader etc. similar to that described in the previous example.

The main difference between this embodiment and the previous one is that here is applied only one liquid filling hose, i.e. there is not arranged any return hose for any gaseous phase from the mobile tank. Under filling operations of the mobile tank, mainly liquid phase cryogen enters the tank through fluid dispensing means 104 that can be a flexible hose. At the end of the fluid dispensing means there is arranged a connector 105 that matches connector 106 associated with the mobile tank 102. The filling operation can be started as soon as the connectors are brought together and the terms of payment accepted. As soon as liquid cryogen starts to enter into the mobile tank 102, any gas flashed off can be evacuated through a muffler 110 controlled by check valves 108, 109 of appropriate settings. These check valves shall ensure that on the one hand that there is maintained a certain counter pressure in the filling operation and on the other hand that the pressure inside the tank will not exceed a certain level of security reasons. Inside the tank there may be arranged a level detecting system 123, such as a capacitor or droplet based system, to detect when the maximum filling level has been reached. The filling can then be stopped either by producing an audio-signal warning the operator or by any sort of communication between the detecting system 123 and the CPU controlling the system. The filling operation may be interrupted by sensing the counter pressure in the mobile tank as well, similar to existing system for fuel tanking.

Claims

1. Method for distribution and sales of cryogenic fluids, in particular CO_2, **characterized** in a system of automated filling stations for cryogenic fluids, the filling station for cryogenic fluids including at least a stationary storage tank (1) and dispenser (3) with at least one fluid dispensing means (4, 8) and a quick connector (5) for easy connection to a mobile tank (2) on a truck or the like.

2. Method according to claim 1, **characterized** in that the individual filling station for cryogenic fluid is accessible by means of credit cards.

3. Method according to claim 1, **characterized** in that the cryogenic fluid is filled by means of gravity.

4. Method according to claim 1, **characterized** in that the fluid dispensing means comprise at least one flexible hose (4, 8).

5. Method according to claim 1, **characterized** in that the cryogenic fluid is separated into a liquid phase in a separator (20) before filling it into the mobile tank (2).

6. Filling station for the filling of fluids, in particular cryogenic refrigerants such as CO_2, from a storage tank (1) to a mobile tank (2) for instance on a vehicle, the filling station including beyond the storage tank (1) and required piping, a dispenser (3) with metering equipment for metering the fluid and at least one fluid dispensing means (4) with a connector for connection to the mobile tank to be filled,
characterized in a pressure/flow control column (30) with a phase separator (20) provided between the stationary storage tank (1) and the dispenser (3).

7. Filling station according to claim 6,
characterized in that the phase separator (20) is provided on top of the pressure/flow control column (30) at a level above the top level of the mobile tank (2), whereby the transfer of fluid from the phase separator (20) to the mobile tank is accomplished by means of gravity.

8. Filling station according to claim 7,
characterized in that the fluid dispensing means comprises two flexible hoses (4, 6).

9. Filling station according to claim 8,
characterized in that the connection for connection of the hoses (4, 6) to the mobile tank (2) is in the form of a two-port one-piece quick connector.

10. Filling station according to claim 6,
characterized in that the fluid dispensing means (4, 8) are provided with break-away couplings.

11. Filling station according to claim 6,
characterized in that, under the filling of the mobile tank, the liquid CO_2 pressure in the control column (30) is reduced by means of a back pressure regulator (18).

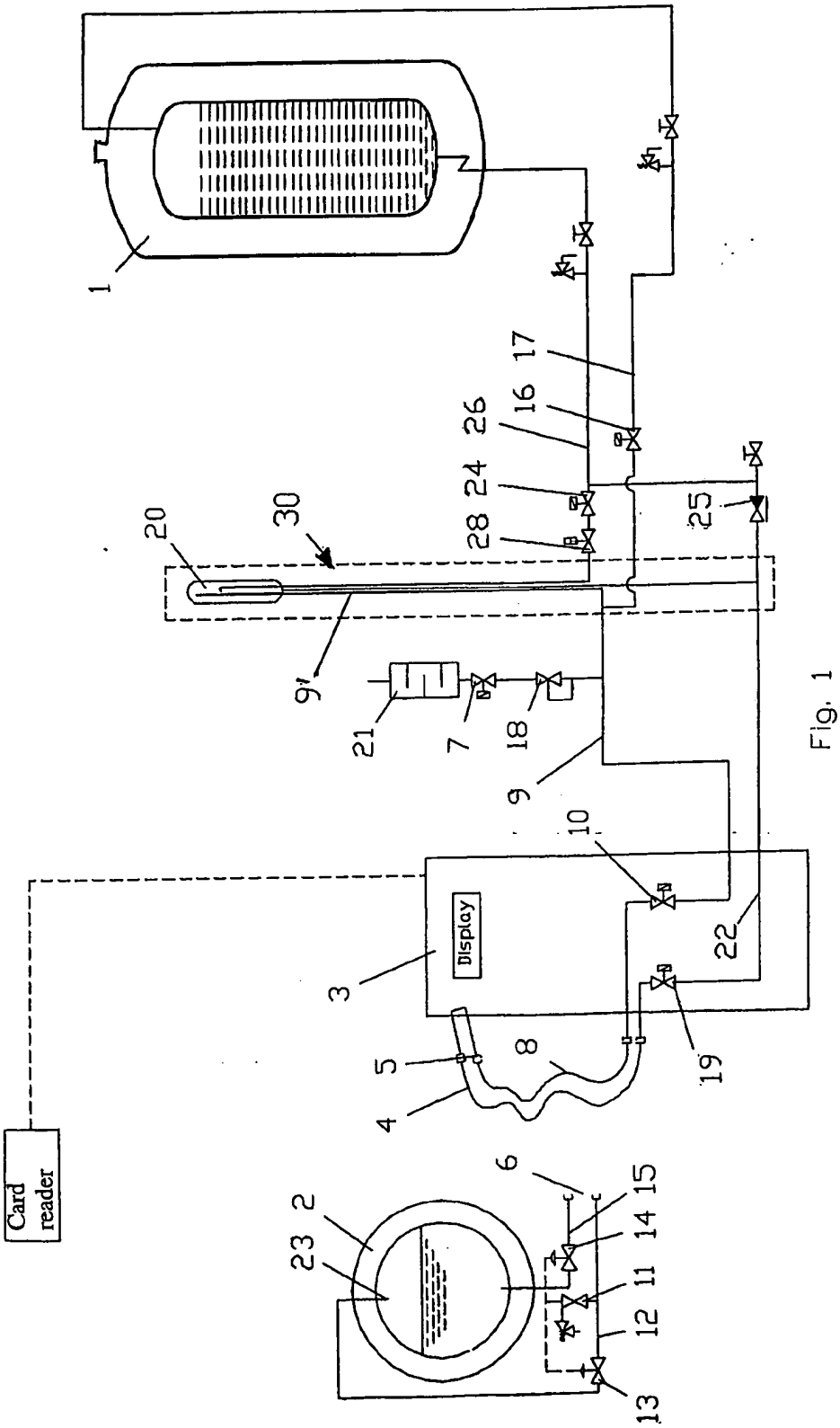
12. Filling station according to claim 6,
c h a r a c t e r i z e d in that a muffler (21) is provided in the piping between the phase separator and the dispenser (3).

13. Filling station according to claim 6,
c h a r a c t e r i z e d in that the muffler (21) forms an integral part of the control column (30).

14. Filling station according to claim 6,
c h a r a c t e r i z e d in that the pressure in the gas hose (8) of the filling station accomplishes opening of actuators of valves (13, 14) on the pipes (12, 15) for filling of liquid and evacuation of gas from mobile tank, whereby the pressure in the mobile tank is automatically stabilized.

15. Filling station according to claim 6,
c h a r a c t e r i z e d in that the valves (13, 14) on the pipes (12, 15) for filling of liquid and evacuation of gas from mobile tank are activated by the physical integration of the connecting piece.

16. Filling station according to claim 6,
c h a r a c t e r i z e d in that the filling procedure is terminated by detection of liquid droplets in the mobile tank (2).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Card reader
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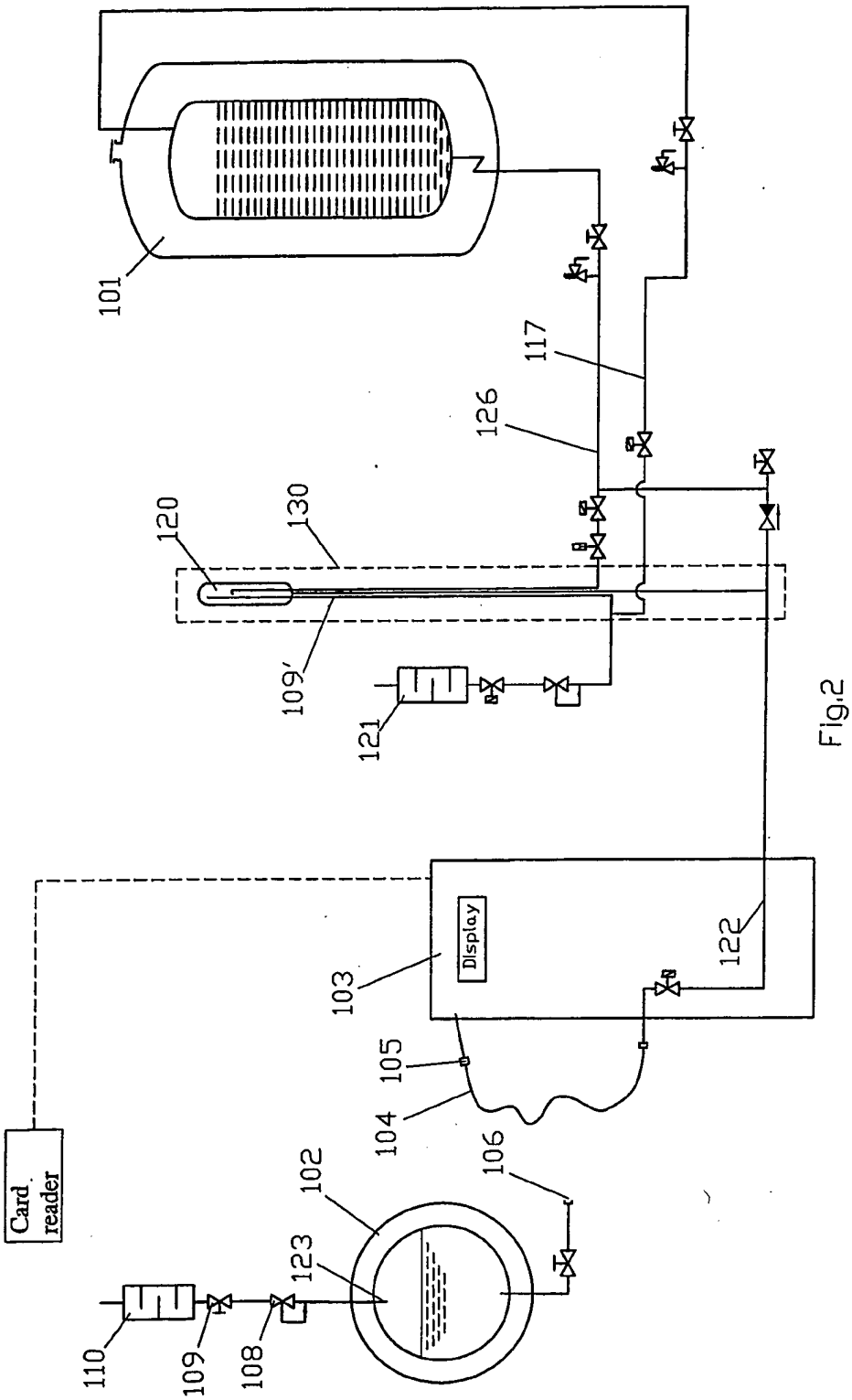
Fig. 1

2/2


101
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Card reader

Fig.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 02/00493

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F17C 5/02, F17C 7/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F15C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4059424 A (BENTZ), 22 November 1977 (22.11.77), claims 1,2,11	1,3-13,15,16
Y	--	2,14
X	US 6142191 A (SUTTON ET AL), 7 November 2000 (07.11.00), abstract	1,4
	--	
Y	US 5259424 A (MILLER ET AL), 9 November 1993 (09.11.93), column 12, line 68 - column 13, line 7	2
	--	
Y	US 1897167 A (R.W. THOMAS), 14 February 1933 (14.02.33), page 2, line 120 - line 121	14
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 March 2003	12 -03- 2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anna R-Salomonsson / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO02/00493

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

.../...

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

The application is not considered to comply with the requirements of unity of invention:

The method for distribution and sales of cryogenic fluids defined in claim 1 is not novel in relation to the apparatus and method of metering and transfer of cryogenic liquids disclosed in US, A, 6142191. Thus, the dependent claims 2-5, as drafted, relate to four different inventions.

The invention according to claim 2 relates to the accessibility and payment of the cryogenic fluid. The inventions according to claims 3-5 relate to the filling of the cryogenic fluid.

No technical relationship, within the meaning of PCT Rule 13, can be identified between the invention defined by claims 2 and the inventions defined by claims 3-5. However, all of said inventions could be searched without effort justifying an additional fee.

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/12/02

International application No.
PCT/NO 02/00493

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 5653269 A	05/08/97
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		MX 9301727 A	29/07/94
US 1897167 A	14/02/33	NONE	